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Changes in the Thermal Regime After Prescribed Burning and Select Tree Removal (Grass Camp, 1975)

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CHANGES IN THE THERMAL REGIME AFTER PRESCRIBED BURNING AND SELECT TREE REMOVAL (GRASS CAMP, 1975)

Reference Abstract

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1978. Changes in the thermal regime after prescribed burning and select tree removal (Grass Camp, 1975). USDA For. Serv. Res. Pap. PNW-234, 17 p., illus. Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

Thermal regimes at several locations are examined following prescribed burn or mechanical removal of shading vegetation. While the forested control location indicated a trend in 1976 toward cooler and less variable air and soil temperatures, treated locations responded vigorously to changing site exposure. Moderate increases in air temperature maxima at sensor height of 0.5 m were noted at treated locations while soil temperature maxima at 0.01 m increased by 8° C on the grass slope and by 26° C in the burned snag patch. Double mass plots of accumulated degree hours illustrate the changing relationship between sites and indicate future trends as sites become revegetated.

KEYWORDS: Temperature (soil), soil temperature, air temperature (-site, fire use, fire effects, prescribed burning, vegetal cover -) fire control.

RESEARCH SUMMARY

Research Paper PNW-234

1978

This Research Paper presents data on changes in air and soil temperature following prescribed fire in two plant communities at 1730 meters near Wenatchee, Washington. These results are intended for use by plant ecologists, biologists, and others who are interested in microclimatic changes following fire at this high elevation site.

Introduction

Prescribed fire offers promise as a management tool on east Cascade forest and range sites. Applications vary in size from treatment of individual plants (eradication of sagebrush or other brush species on rangelands, Hallman 1972) to the multiacre stand manipulation as in this example. The prescribed fire at Grass Camp, Wenatchee National Forest, eastern Washington, on September 30, 1976, was an operational test of prescribed fire to improve wildlife habitat (primarily for elk) and to control the encroachment of brush and tree species into a nearby high elevation (1 730 m) meadow. Three areas were designated for treatment: a grassy slope with invading lodgepole pine, a felled area with a high concentration of new slash, and an older snag thicket with a large accumulation of dead standing and windthrown material. Our measurements concentrated on the grassy slope and the snag thicket.

Burning of the grassy slope was not accomplished as originally planned. A hasty decision was made to increase site exposure by felling the small lodgepole pine shading this site, thus crudely simulating what fire and later windthrow might have accomplished, i.e., complete overstory removal.

A pretreatment aerial photo (fig. 1) indicates general site conditions: the inset map shows geographic location. A posttreatment photo (fig. 2) taken in 1976 shows extent of burn in the snag thicket. Indicated also on these photos are the instrumented locations (control, grass, and snag).

Stand conditions in the snag thicket are illustrated in figure 3. Accumulation of windthrown trees, standing snags to 20 m, and reproduction of all ages made access difficult. Figure 4 (foreground) shows the sparse cover on the grassy slope with isolated patches of young lodgepole pine. The control stand, lodgepole pine to 20 m tall, had complete canopy closure with only isolated grass and low shrub ground cover. Soils at all locations were derived from underlying basalt.

State college, university, and Pacific Northwest Forest and Range Experiment Station personnel are examining effects of this prescribed burn on local animal and plant communities. Plant and animal responses are intimately related to changes in the thermal regime; thus, results reported here may assist other workers in their evaluations. Direct measurement of the thermal regime, especially within the zone nearest the forest floor, is absent in other contemporary studies on this site.

Short- and longterm effects on the thermal regime after fire are of recognized importance in re-establishment and successional trends of the residual or new plant community. After the 1970 wildfire on the Entiat Experimental Forest, we found no significant changes in the July-August air temperature regime at weather shelter height. Measurements at this standard height, however, normally minimize the local microsite variability experienced nearer the soil surface. Postfire measurements on the soil surface showed highly variable maximum temperatures; temperatures strongly influenced by soil surface condition, type, and quantity of vegetation (Helvey et al. 1976). Air temperature at 0.5 m related well to phenologic development of a selected forb and shrub[1/] found in this elevational zone.[2/] Sampling

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[1/] *Apocynum androsaemifolium* L. and *Spiraea betulifolia* Pall.

[2/] Unpublished information on file at the Forest Hydrology Laboratory, Wenatchee, Washington.

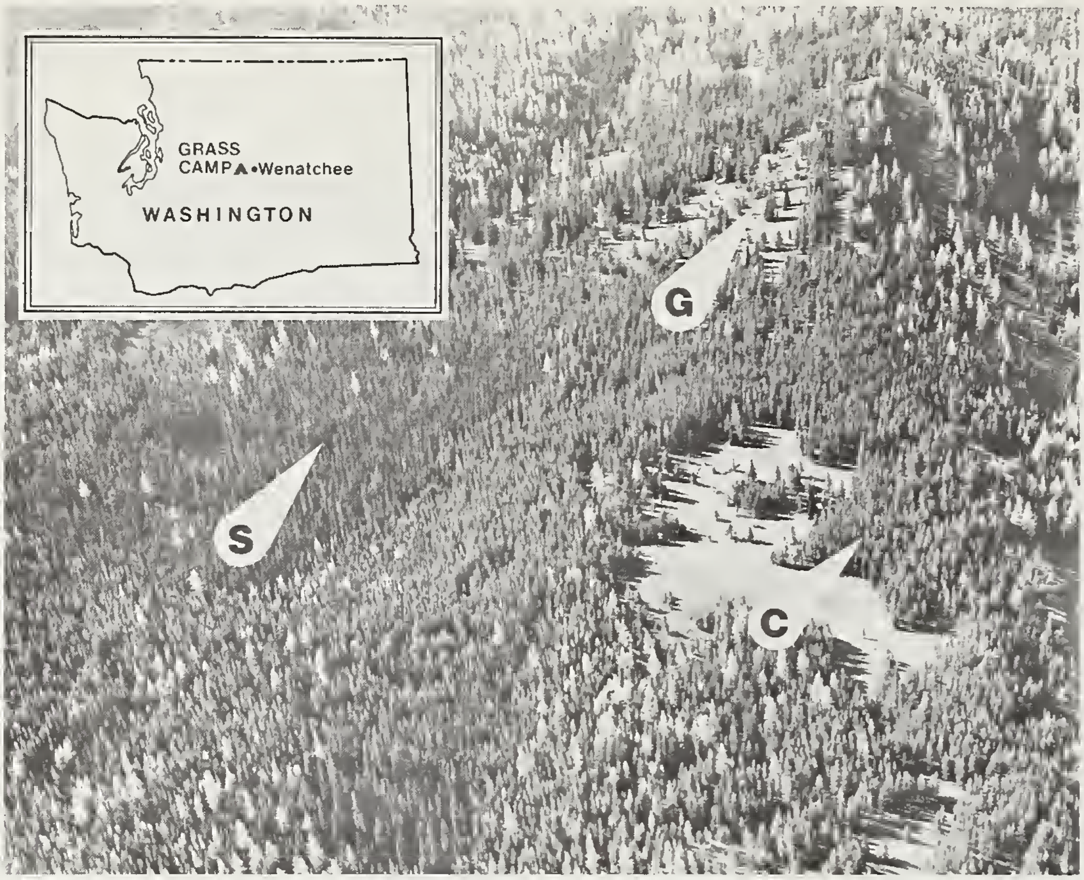

Figure 1.--Pre-treatment view (towards southwest) of prescribed burn area. Instrumented sites, control (C), grass slope (G), and snag patch (S) are identified. Inset map shows location within Washington State.

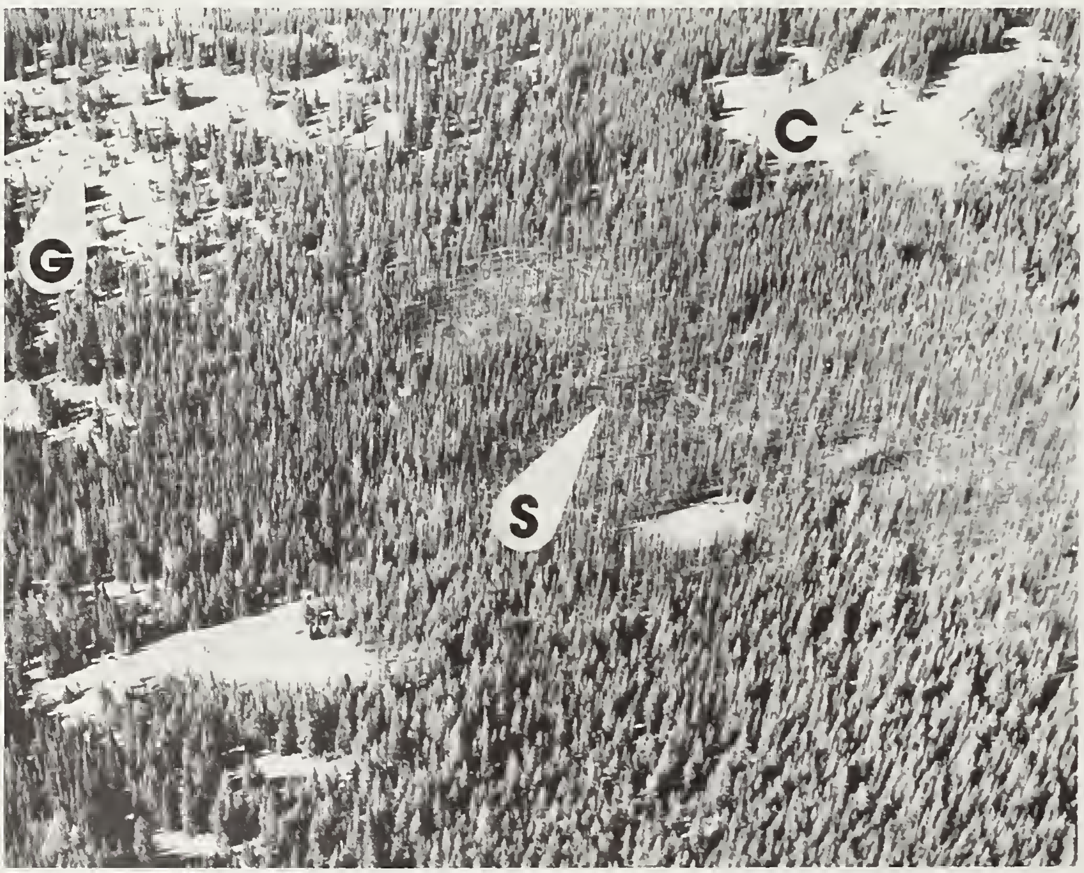

Figure 2.--View towards northwest after prescribed burn of snag patch. Instrumented sites are indicated.

Figure 3.--Layered vegetation with standing and windthrown snags typified fuel conditions in snag thicket. Metal stand for temperature sensors may be visible near kneeling researcher.

Figure 4.--Encroaching lodgepole pine on grassy slope in foreground. Snag thicket burning in background.

at the 0.5-m height and at the soil surface was therefore selected for the Grass Camp study. We felt that this height would be more revealing of local microsite temperature differences than standard weather shelter height and that it was within the microclimatic zone for re-establishing species.

With vegetation control one of the primary objectives of this burn, it was desirable to observe temperatures during the burn for subsequent explanation of observed plant response. Lethal temperature for protoplasm is about 50-60° C (120-140° F) for most plant tissue (Davis 1959, Meyer and Anderson 1952). Shielding of critical cambial tissue by thicker bark allows some plants to withstand much higher local temperatures. A fire of moderate intensity should kill the thin-barked species (spruce, fir, and lodgepole pine) found at this elevation.

Literature on air temperature distribution during prescribed burns in the east Cascades is limited. Temperatures are in response to fuels, moisture content, and local controls on combustion rates. Davis (1959) suggests temperatures of 1800° F (982° C) for low moisture fuels, 1600-1700° F (871-926° C) for fuels with high moisture contents of 40 percent or more, and that soil surface temperatures of 400° F (204° C) to 900° F (482° C) are common.

Materials and Methods

Two types of maximum temperature sensors (metals and temperature-sensitive wax compounds) were installed in the snag thicket on the day of the fire (September 30, 1975). Melting point for maximum temperature sensors ranged from 183° C to 1 085° C (361° F to 1985° F). Metals: copper, aluminum, lead, and a lead-tin mixture had melting points of 1 085, 660, 327, and 183° C, respectively. Thermoplastics with melting points of 815, 732, 593, 537, 482, 426, 371, and 260° C supplemented the metals for 11 fixed points of maximum temperature measurement. Sampling heights varied and were up to 7 m above the forest floor. Nine sample points were located in a random pattern in the snag thicket. All locations were within 20 m of the recording site in an approximately circular pattern. A 10th location was in the adjoining lodgepole pine stand.

Recording integrating soil and air thermometers, operating on a 3-hour print cycle, were installed at a control location, snag thicket, and on the grassy slope. These recording devices were operated through the latter part of July until mid-October or early November 1975, and from June through September or October 1976. Instrument location on the grassy slope was on the shaded uphill edge of a sparse group of small lodgepole pine trees (3 m in overall diameter; trees to 3 m tall).

The recording thermometer produced a degree-hour summary above a reference temperature of -10° C[3/] or by conversion, calculated the average temperature for each 3-hour period. Sample heights were 0.5 m for air temperature and 0.01 m for soil temperature; accuracy and resolution of the measurement is ± 1 count per 3-hour period or ± 0.2° C.

Results

AIR TEMPERATURE DURING BURNING

A pictorial summary of maximum air temperatures at the selected heights and from the cable-supported sensors is shown in figure 5. For

[3/] A reference temperature of -10° C allowed the thermometer to register temperature excursions below freezing.

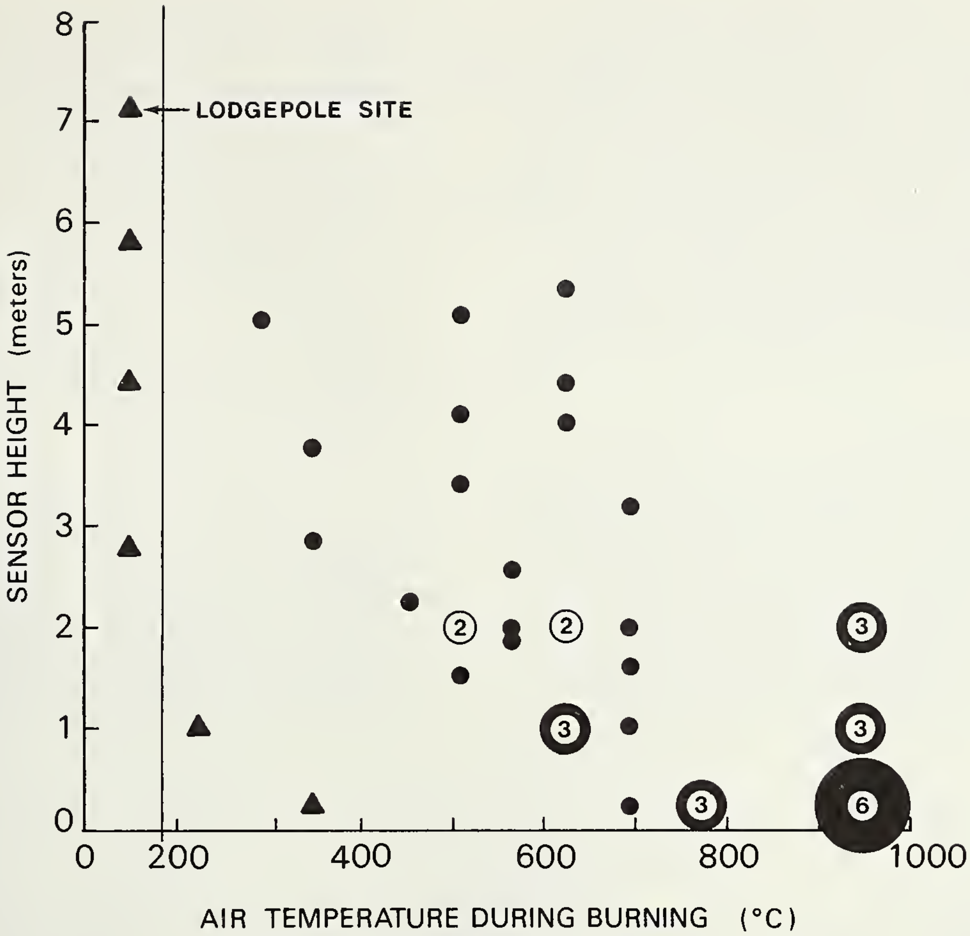

Figure 5.--Temperature-height distribution during burning of snag thicket (spruce-fir) and lodgepole pine stand. Duplicate measurements shown by number and diameter of symbol.

locations within the snag thicket, the range of temperature at each height and frequency of occurrence is shown plus the temperature profile for the single lodgepole pine location. Each measurement (height-temperature) is represented by a point in the figure. A variation in height of cable-supported sensors is noticeable. At locations where support for the cable was lost during the fire, measurements are shown at heights measured after the fire. Separate profiles for each location within the snag thicket are not shown due to overlapping of data points. Measurements were not available at six points due to loss of temperature sensors from falling debris or unknown causes.

All temperatures were within the measurement range of the sensors except for the four measurements less than 183° C (361° F) in the lodgepole pine stand. Resolution suffered in the grouping of data in the 815-1 085°C (1500-1985° F) range between the two highest responding sensors at the three lower levels of measurement. Each plotted point represents the midpoint of a temperature range (e.g. 221° C for the 183° C to 260° C range, at 950° C for the 815° C to 1 085° C range, etc).

AIR AND SOIL TEMPERATURE

In contrast to the short-term temperature history during the fire (fig. 5), air and soil temperatures at the three locations over the 2 years present a variable, interrelated picture. Averaging of the data over

too long a time period reduces the resolution, damps out or at times even obscures the response. Analysis of the data, based on a minimum of 12-hour day versus night,[4/] is desirable to isolate these different energy input periods. To understand the differences between several sites during the 12-hour period, a brief analysis of three hourly periods for the snag soil and control soil is shown.

Simple graphical analysis for the various combinations of control versus treated sites indicated that the treatments affected the thermal regime at these sites. Figure 6 illustrates the response at the grass site for daytime air temperatures compared to the control location.

Daytime temperatures are obviously higher in 1976 than in 1975 for similar control site temperatures. Because of the discontinuous nature of the temperature data caused by the limited temperature excursion after treatment in 1975, the relationship between posttreatment 1975 data to the prior treatment 1975 or 1976 period is undefinable. This treatment of the data also suppresses any temporal or changing relationship within the separate data groups.

We have chosen two alternate procedures (Chow 1964) to examine the changing temperature relationship between the control versus treated sites: the double mass plot of accumulated degree hours and a frequency analysis of observed temperatures.

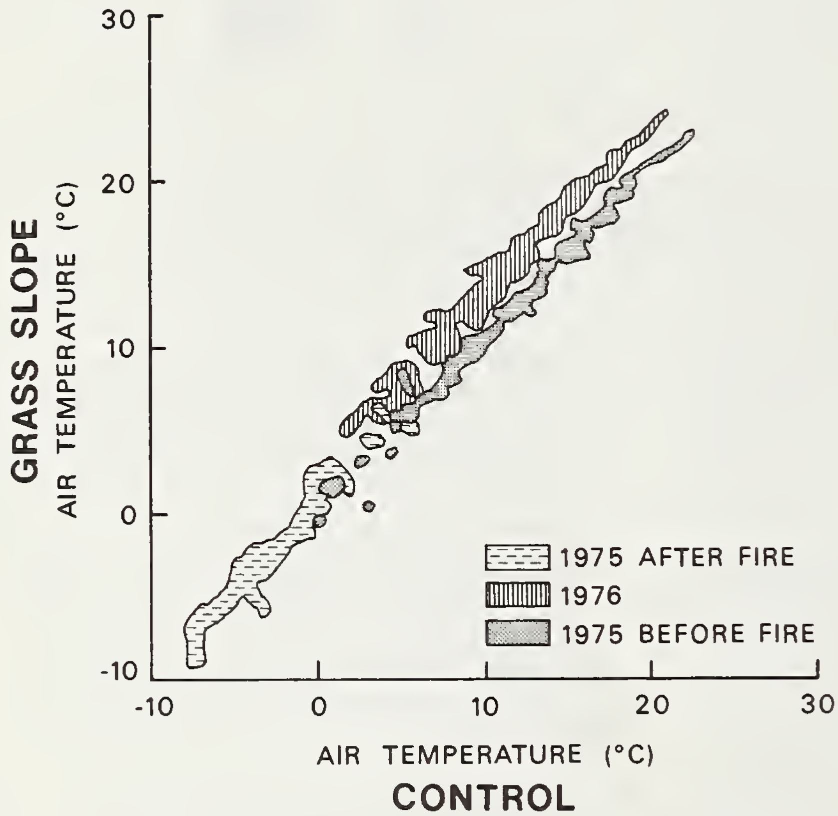

Figure 6.--Relationship between daytime air temperature at control and grass sites for 1975 and 1976.

Accumulated degree-hour summaries for the control versus snag patch and grassy slope based on a 3-hour printout are plotted in figures 7, 8, 9, and 10. Except for the expanded section (daily, i.e. 12-hour accumulations)

[4/] Daytime = between 0600-1800 hours. Nighttime = between 1800-0600 hours.

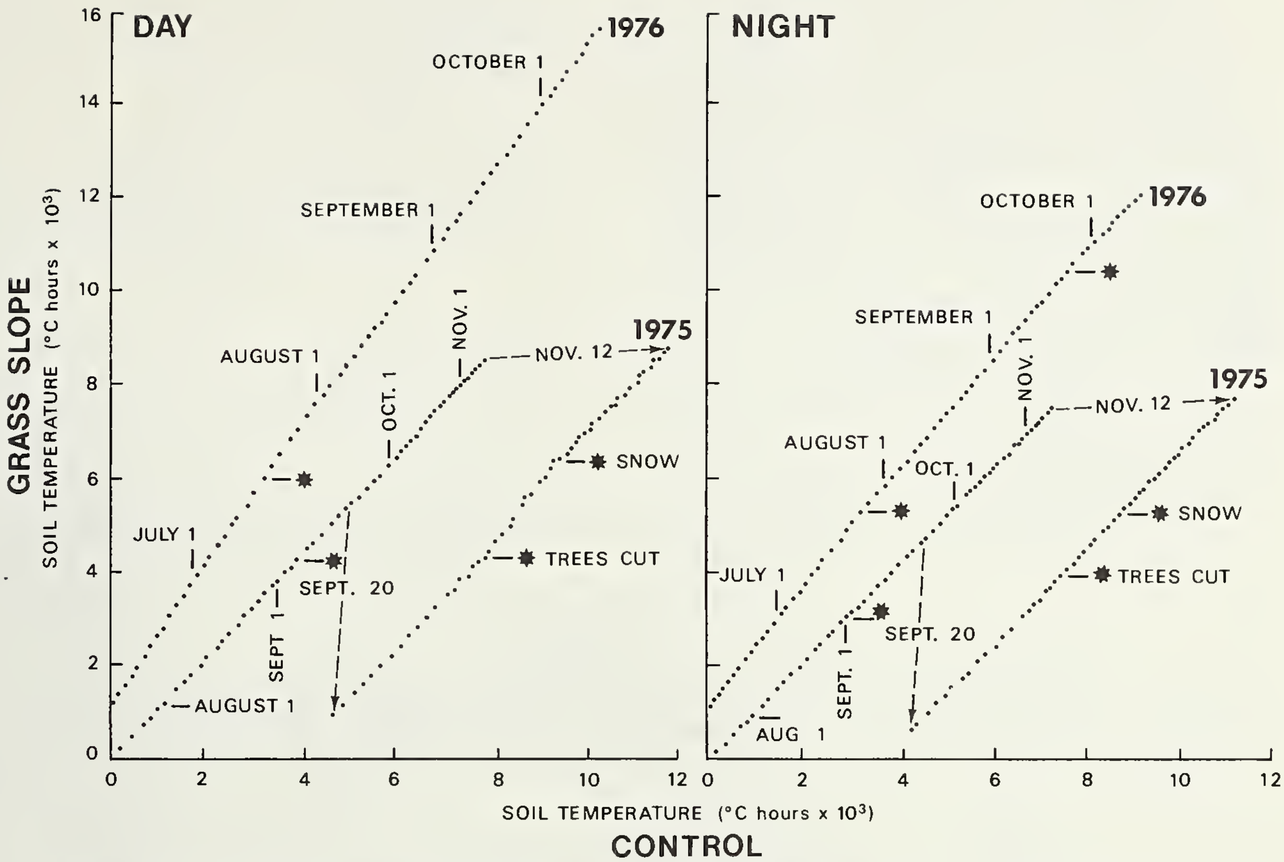

Figure 7.--Double mass plot of accumulated degree hours for control soil and grass soil (1975 and 1976). Expanded portions are September 20, 1975, to November 12, 1975. Significant slope change is indicated by an asterisk.

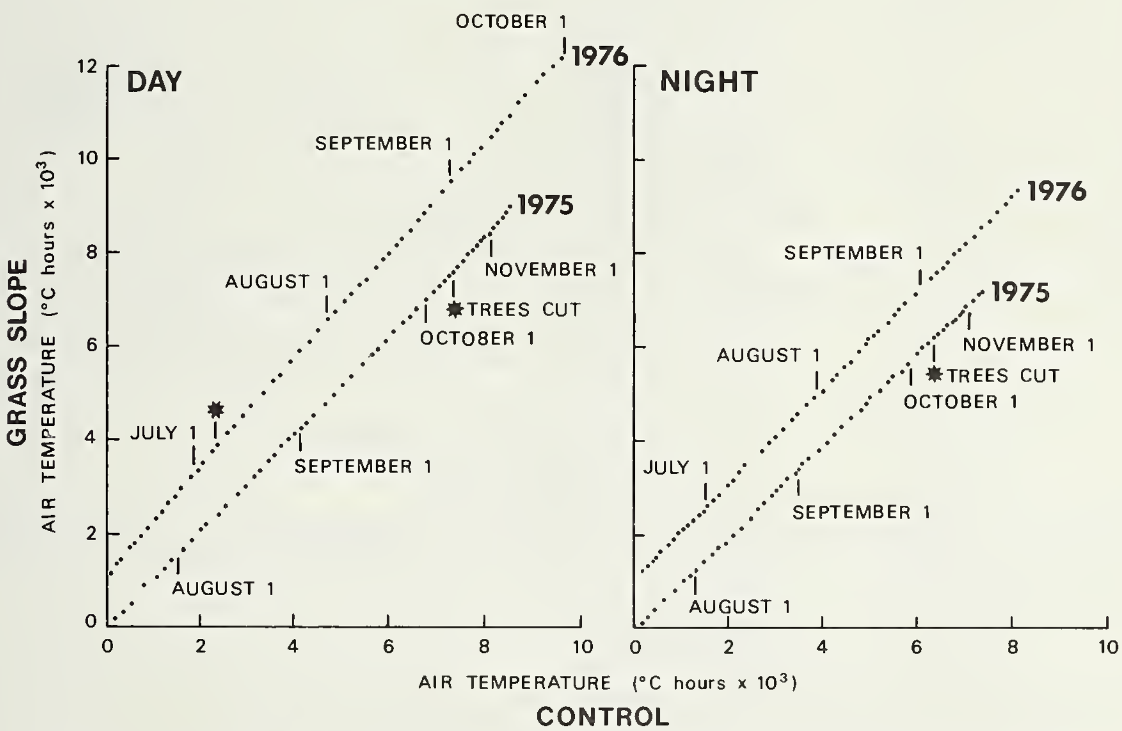

Figure 8.--Double mass plot of accumulated degree hours for control air and grass air (1975 and 1976). Significant slope change is indicated by an asterisk.

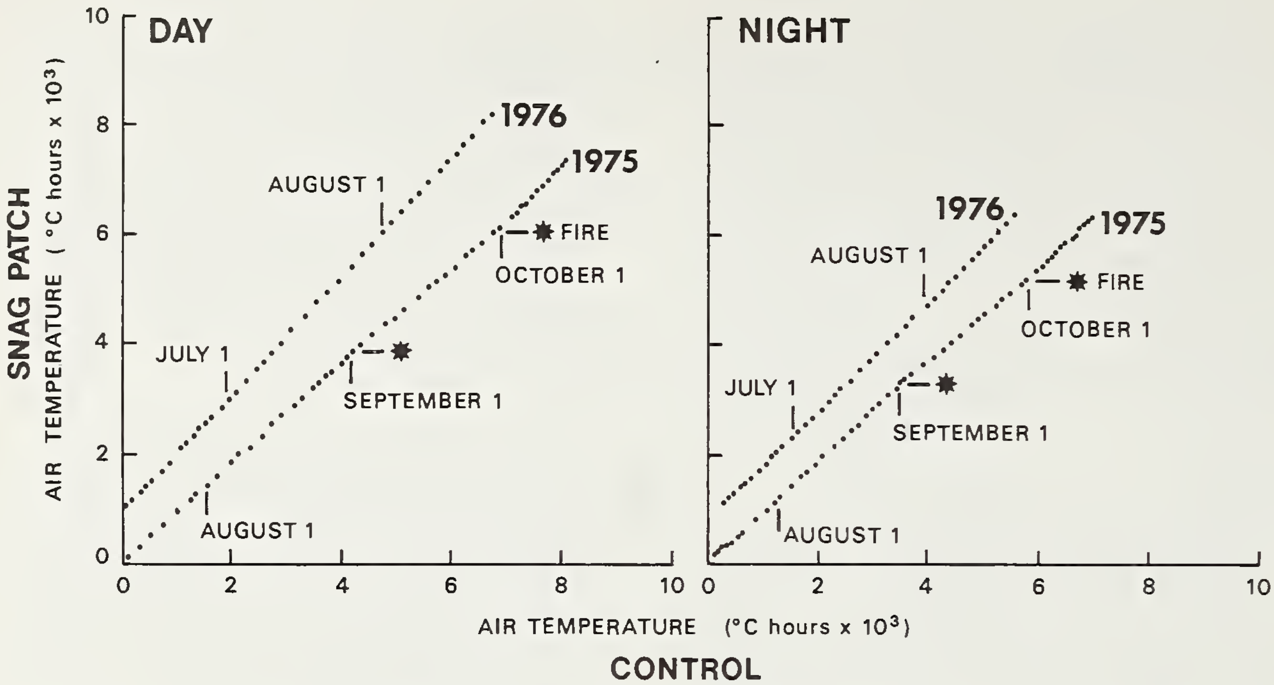

Figure 9.--Double mass plot of accumulated degree hours for control air and snag air (1975 and 1976). Significant slope change is indicated by an asterisk.

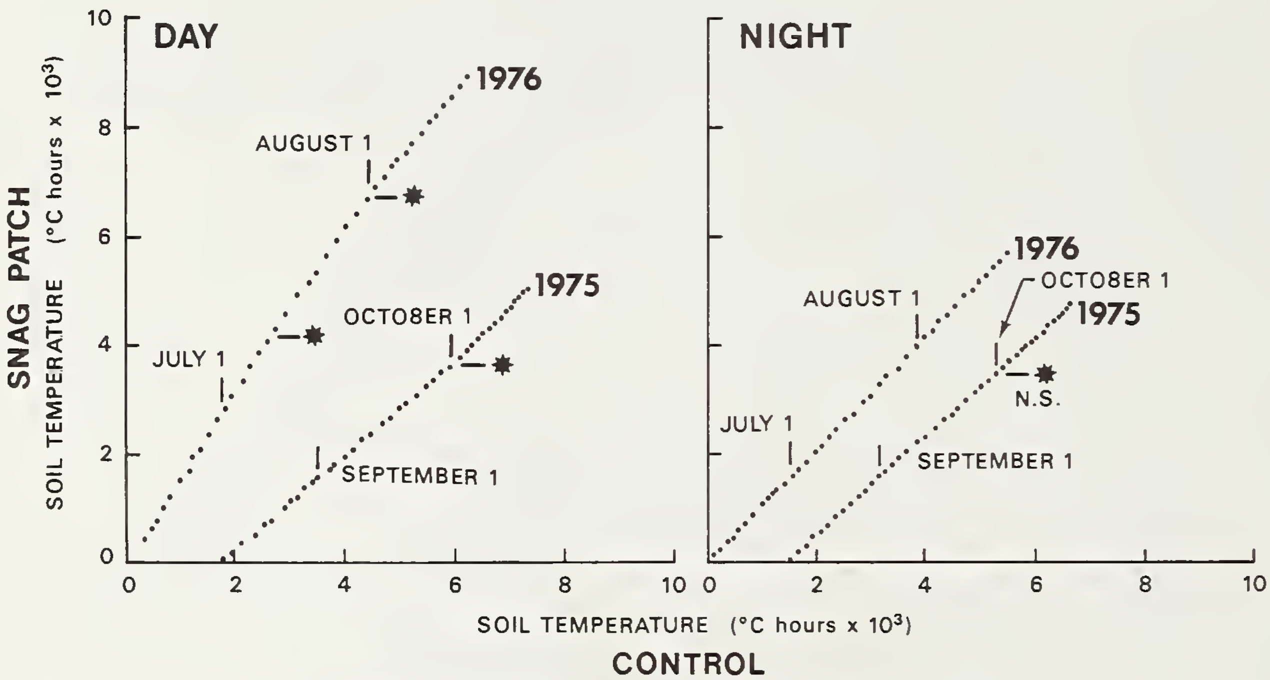

Figure 10.--Double mass plot of accumulated degree hours for control soil and snag soil (1975 and 1976). Significant slope change is indicated by an asterisk.

in figure 7, each point represents a 48-hour accumulation. If the rate of degree-hour accumulation progresses at two sites at some relatively constant rate, the plot is linear. If there is a statistically significant change in the slope, we can speculate on some changing condition(s) affecting the thermal regime at one of the sites.

On figures 7, 8, 9, and 10, the degree hours for both 1975 and 1976 are shown, and are divided into nighttime and daytime for soil and air. The comparison in each case is between the untreated control site and either the grassy slope or the snag thicket.

Tests were made for changes in slope when treatments were made (September 30 for the snag thicket and October 10 on the grassy slope) and at times indicated by a graphical discontinuity in the slope. Periods of testing are separated by asterisks on the plots. In general, all changes in slope shown on the daytime plots are significantly different (p = 0.01 or better) in all combinations within a year and between the 2-year period. Similarly, most night comparisons are found to differ significantly in slope except for those noted as N.S. on the plots. A tabular summary of periods tested and slopes are shown in table 1.

Table 1--*Comparison between slope of degree hour accumulation (Grass Camp - 1975, 1976). Unless indicated as N.S. (nonsignificant), all possible slope comparisons differ significantly, p = 0.01 or better*

Comparison	Period	Slope
Control Soil (Day) vs. Grass Soil (Day)	7/22/75 to 9/5/75	1.0807
	9/6/75 to 10/9/75	1.0349
	10/10/75 to 10/20/75	1.3014
	10/21/75 to 11/12/75	1.0004
	6/4/76 to 7/22/76	1.5016
	7/23/76 to 10/19/76	1.3329
Control Soil (Night) vs. Grass Soil (Night)	7/22/75 to 8/27/75	1.0456
	8/28/75 to 10/9/75	1.0104
	10/10/75 to 10/20/75	1.0731
	10/21/75 to 11/12/75	1.0012 N.S.
	6/4/76 to 7/26/76	N.S. 1.2851
	7/27/76 to 9/23/76	1.1896
	9/24/76 to 10/19/76	1.0436
Control Soil (Day) vs. Snag Soil (Day)	8/9/75 to 9/29/75	0.8861
	9/30/75 to 10/28/75	1.0155
	6/4/76 to 7/12/76	1.6407
	7/13/76 to 7/29/76	1.4939
	7/30/76 to 10/25/76	1.2128
Control Soil (Night) vs. Snag Soil (Night)	8/9/75 to 9/29/75	0.9246 N.S.
	9/30/75 to 10/28/75	0.9106
	6/4/76 to 10/25/76	1.0440
Control Air (Day) vs. Grass Air (Day)	7/17/75 to 10/9/75	1.0347
	10/10/75 to 11/12/75	1.0979
	6/4/76 to 7/6/76	1.2039
	7/7/76 to 9/29/76	1.1376
Control Air (Night) vs. Grass Air (Night)	7/17/75 to 10/9/75	0.9799 N.S.
	10/10/75 to 11/11/75	0.9722
	6/4/76 to 9/29/76	1.0298
Control Air (Day) vs. Snag Air (Day)	7/17/75 to 9/1/75	0.9426
	9/2/75 to 9/29/75	0.8927
	9/30/75 to 10/28/75	1.0442
	6/4/76 to 8/28/76	1.1158
Control Air (Night) Snag Air (Night)	7/17/75 to 9/1/75	0.9411
	9/2/75 to 9/29/75	0.8340
	9/30/75 to 10/28/75	0.9919 N.S.
	6/4/76 to 8/25/76	0.9908

1/ All possible comparisons are significant except those shown as N.S. with arrow brackets.

Soil temperature in grass area.--Of particular interest and illustrative of the sensitivity of this procedure is the expanded section for the period September 20, 1975, to November 12, 1975, on the control soil and grass soil double mass plot (fig. 7). Removal of shading vegetation allowed direct beam solar insolation to reach the soil surface. An immediate response (slope change) both day and nighttime occurred with the soil warming, only to be terminated as both grassy slope and control became snow covered on October 20. Ratio between control and grassy slope soil degree-hour accumulation for both night and day under the snow was virtually 1:1 (table 1).

During 1976, the temperature accumulation showed the higher energy input from the unobstructed sun; slope of the degree-hour accumulation is much greater than 1975 values. Other significant slope changes are noted on the plots for 1975 and 1976 in this figure 7 (and others) not identified with direct site treatments. These slope changes are discussed below relative to the changing temperature distribution within the individual 12-hour averaging periods.

Air temperature in grass area.--The day air temperature at this location (fig. 8) showed the effect of treatment (becoming warmer than control) but not of the snow cover. The grassy slope after snowfall maintained its slightly warmer day air temperature regime created by removal of the vegetation. The night air temperature (fig. 8), however, showed no significant slope change in degree-hour accumulation after treatment in 1975 compared to the control site.

In 1976 both day and night air temperatures at 0.5 m were consistently higher than control values.

Air temperature in snag area.--The snag thicket night air temperatures (fig. 9) continued the warmer than control trend established after the fire in 1975 with a nonsignificant slope difference between all of 1976 and the posttreatment 1975 trend. Snag day air temperatures are slightly warmer in 1976 than the terminal posttreatment period in 1975. Both posttreatment 1975 and 1976 periods follow a slope greatly different than in the pretreatment 1975 period.

Soil temperature in snag area.--After the fire in 1975, the night soil temperatures in the snag patch showed a nonsignificant but slightly negative slope change, a continuation of a prefire slope of less than 1:1. The night soil temperatures thus were generally cooler than the control prior to the fire and possibly even somewhat cooler after the fire. In 1976 control and snag soil temperature accumulations were essentially equal; significantly different from the 1975 values.

At the snag patch soil surface during day hours in 1976 (fig. 10), the temperature regime becomes more complex with two slope changes observed in 1976. Slopes for the degree-hour accumulations during the three periods in 1976 also differ significantly from the 1975 plot during both the pretreatment and posttreatment periods.

Figure 11 illustrates trends in the 7-day degree-hour accumulations for the snag patch and control soil for each 3-hour time period during the day. The most noticeable difference between these graphs is the obviously greater degree-hour accumulations in the snag patch during all day postfire periods. This accounts for the higher double mass slopes following the fire but does not account for the slope changes noted above. The changing shape of the plotted accumulation for the individual 7-day time periods indicates one of the factors controlling the slope variability seen for this (and other) locations. The control location shows a consistent 1500 hour

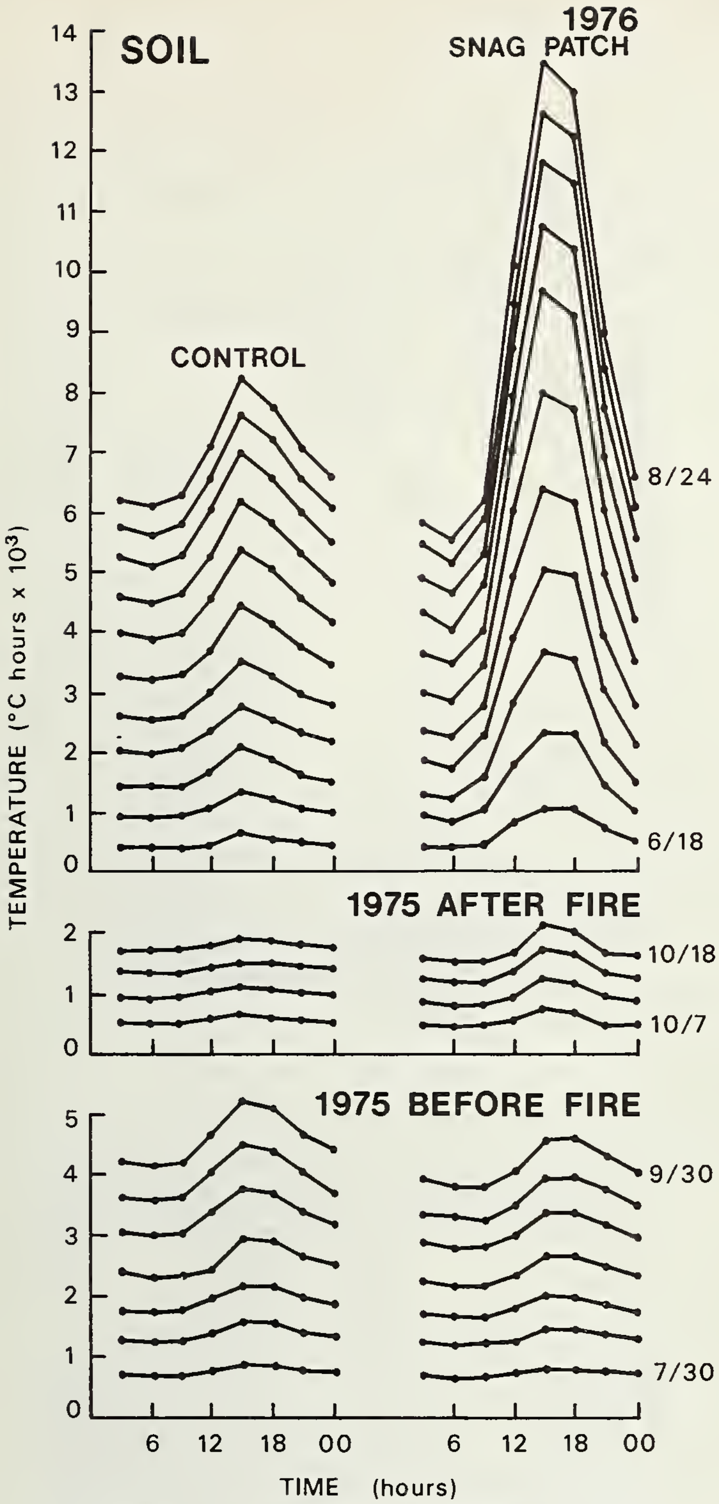

Figure 11.--Cumulative degree hours per time period. Plotted for 7-day intervals for 1975 and 1976.

maximum temperature accumulation through the 2-year period while the snag patch indicates accumulation for both 1500 and 1800 hours nearly identical for the pretreatment and 1975 posttreatment periods. During 1976, the 1800 hour snag patch degree-hour accumulation gradually retreats from the 1500 value; the slope of degree-hour accumulation in the double mass plot thus gradually decreases with time (fig. 10).

We also noted that the snag patch soil night temperature showed a slight but insignificant decline after the fire. The individual degree-hour accumulations for the 3-hour night periods show this decline as well. A general equivalence in degree-hour accumulation for the night period compared to control in 1976 was also noted. Table 1 shows a snag soil to control slope at night of 1.0440 to 1. Recognizing that this is the mean of all night values, if one observes the trend for a single 3-hour period, say 0300 to 0600 in figure 11, the slope of the relationship would have been strongly negative as shown from the depression of the 0300 and 0600 values in figure 11, compared to equivalent control values. It is the greater degree-hour accumulation during the other night periods, notably 2100 and 0000 hours that elevated the averaged night values.

FREQUENCY ANALYSIS OF 3-HOUR MEAN TEMPERATURES

The double mass plot reveals minute changes in degree-hour accumulations accompanying the treatments. Although the plotted values can be converted to an average temperature between each point, much resolution is lost in the process. Occurrence of periods of below freezing temperatures or excessively high temperatures escapes notice. A frequency analysis of mean temperature for each 3-hour period supplies this type of information.

Pretreatment period.--Figure 12 represents pretreatment cumulative frequency distribution for air and soil temperatures for the three sites in 1975. The air temperature frequency distribution for the control and grass sites are remarkably similar. Limits on maxima and minima during the period of record are within the same 2^{o} C class interval. Examination of the actual number of cases within each temperature group (figs. 13 and 14)

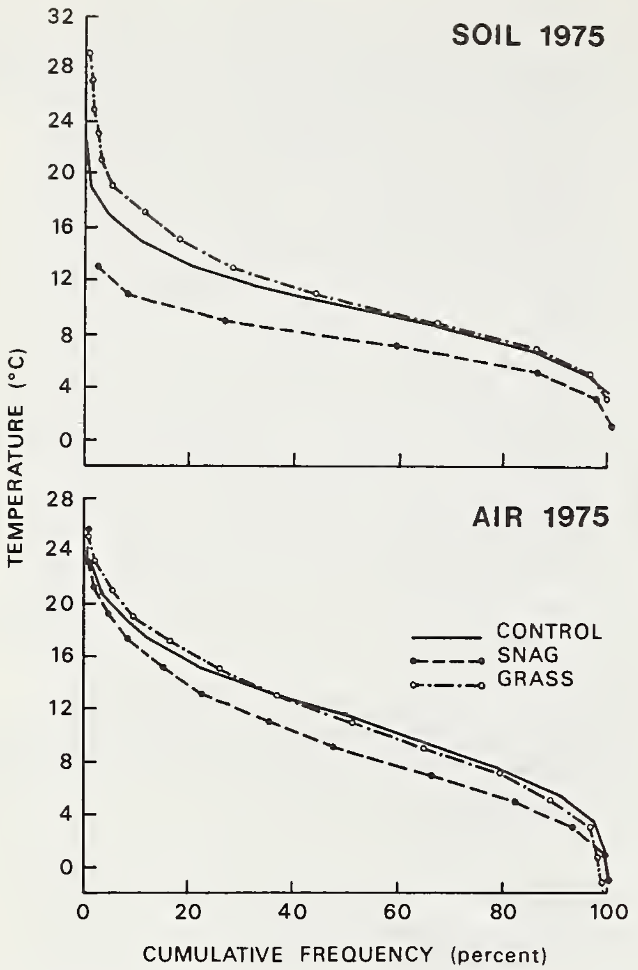

Figure 12.--Cumulative frequency diagram for air and soil temperatures at three sites during the pretreatment period 2-degree class interval.

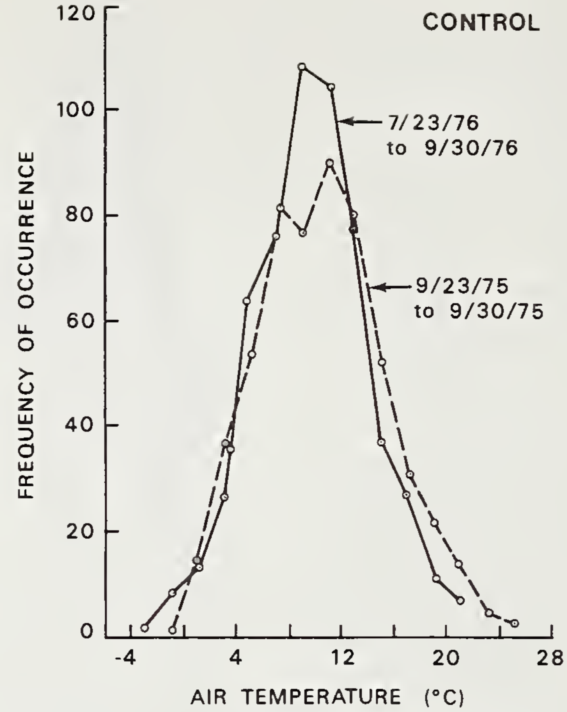

Figure 13.--Control air temperatures-frequency distribution of 3-hour mean temperature (1975 and 1976).

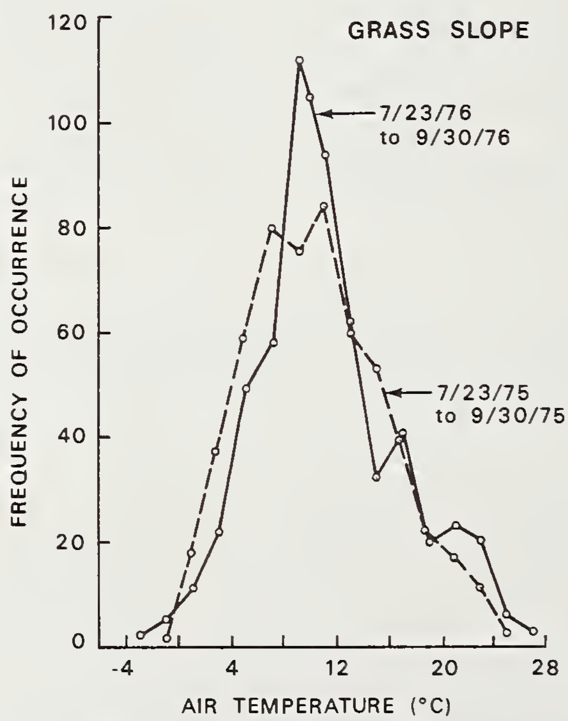

Figure 14.--Grass air temperatures-frequency distribution of 3-hour mean temperature (1975 and 1976).

at these sites indicates a slightly greater number of warmer periods at the grass site.

During the 1975 pretreatment period, the snag patch air temperatures had the same limits for the maximum and minimum values as the control and grass sites (fig. 12). Figures 13, 14, and 15, however, indicate a different distribution of temperatures during this period. Snag patch air temperatures were generally cooler; figure 15 shows most frequently occurring temperature to be within the 6-8° C class. Both the control and grass sites have a similar peak in this temperature class but a larger peak at 10-12° C (figs. 13 and 14). More below-zero air

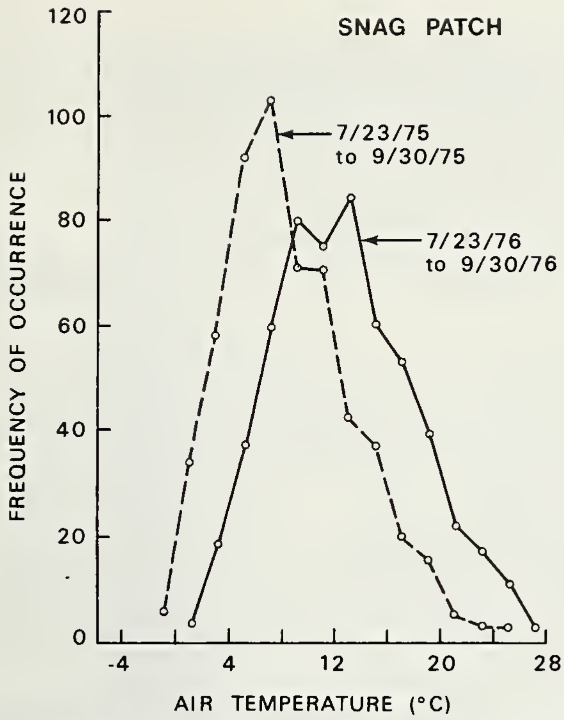

Figure 15.--Snag air temperatures-frequency distribution of 3-hour mean temperature (1975 and 1976).

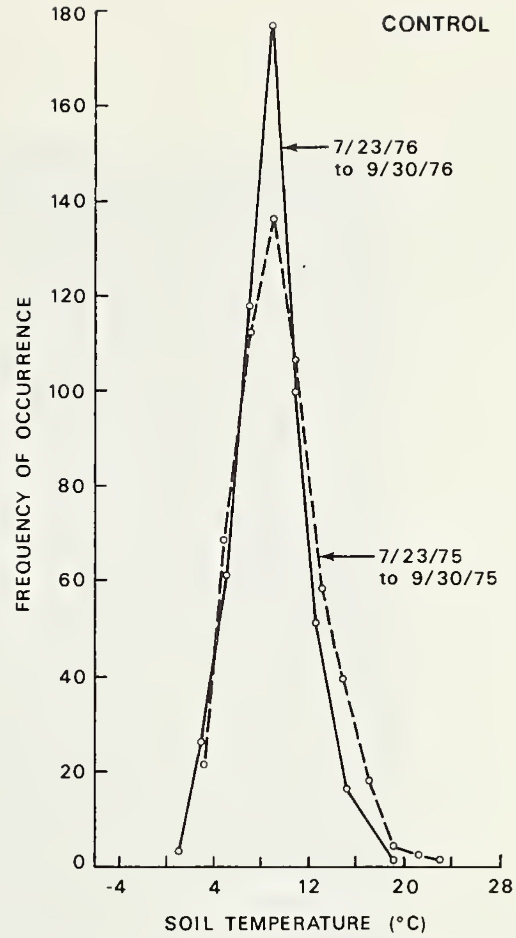

Figure 16.--Control soil temperatures-frequency distribution of 3-hour mean temperature (1975 and 1976).

temperatures were observed in the snag patch, six compared to two at the grass location and one at the control site.

Soil temperatures at these three locations were initially dissimilar. Figure 12 shows the initial pretreatment soil temperature frequency distributions, abstracted from figures 16, 17, and 18. Greatest pretreatment differences existed in the warmer temperature intervals. The dense layer of material near the surface of the snag patch prevented any direct insolation and restricted air exchange, while the soil surface at the grass site at times was intermittently exposed through the sparse canopy.

After treatment.--Figures 13 through 18 illustrate the treatment effects at these sites. Note particularly that in the control areas both air and soil temperatures in 1976 (figs. 13 and 16) have a more sharply

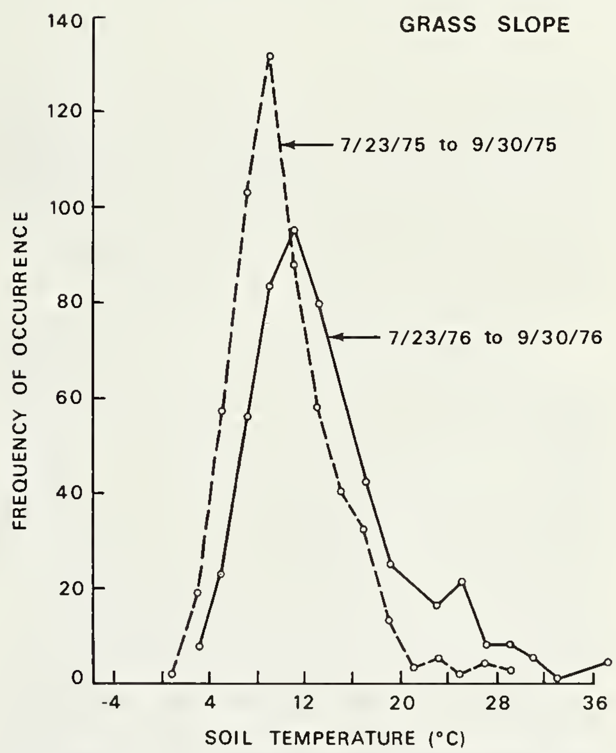

Figure 17.--Grass soil temperatures-frequency distribution of 3-hour mean temperature (1975 and 1976).

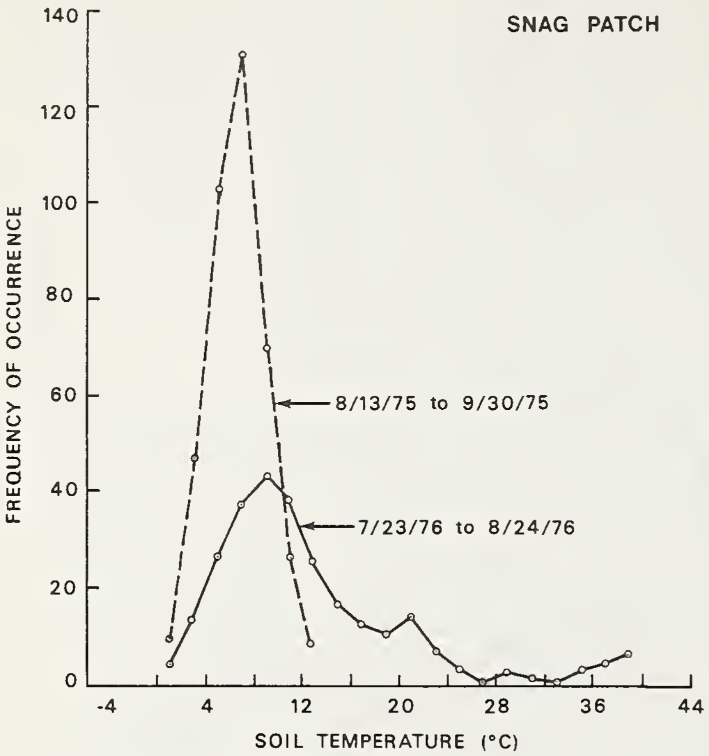

Figure 18.--Snag soil temperatures-frequency distribution of 3-hour mean temperature (1975 and 1976). Note time period change for this figure compared to figures 13 through 17.

peaked distribution (number of periods per temperature class) and a reduction in percentage occurrence of warmer temperature periods compared to 1975 (i.e. a cooler and less variable temperature history in 1976).

Treatment by fire or by shade removal reversed this trend in the snag patch and on the grassy slope. The air and soil temperature on the grassy slope (figs. 14 and 17) shifted towards higher values. More dramatic was the change in the snag patch thermal regime shown in figures 15 and 18. Air temperature maxima (snag and grass) were elevated into the next temperature class, from 24-26° C to 26-28° C; soil temperature maxima increased by 8° C on the grassy slope, by 26° C in the snag patch over pretreatment maxima.

Grassy slope air and soil temperature minima were also lowered in the posttreatment period. Snag air and soil temperature minima did not fall below pretreatment values.

Discussion and Conclusions

Air temperature during burning in the snag thicket within the zone of heavy fuel concentration (the first several meters, with a maximum below 1.25 m) are within the ranges suggested by Davis (1959). Most of the snag thicket temperature measurements at the two lower levels, 0.25 m and 1.25 m, are within the 815-1 085° C (1500-1985° F) temperature range with no measurement exceeding 1 085° C. Our anticipation of a lower temperature burn and consequent emphasis on lower temperature measurements reduced resolution within the 815-1 085° C temperature range. Consumption of many fallen and some standing snags was accomplished at this burn intensity; but as figure 19 indicates, the burn killed all above-ground living material in the snag thicket, resulting in a newly created snag condition.

Air temperatures during burning at the one measurement location within the lodgepole pine stand were much lower. Fire at this location consumed the small accumulations of residue and the regenerating fir and spruce that would have been the future climax stand.

Prior to treatment, air and soil temperatures were found to reflect differing site exposures. Soil temperatures showed a greater pretreatment variablity than air temperatures even though the latter were measured as close to the surface as 0.5 m. The air temperature measurement represents the composite of energy exchange at the soil surface acting on an air column with a continuous but variable vertical and lateral heat exchange.

Figure 19.--Snag patch conditions immediately following prescribed burn. Senior author examining temperature recorder in foreground.

An uncoupling of the air and soil temperature regimes on the grassy slope was noted after the treatment (felling of selected trees in 1975). Day and night soil temperatures responded to the shade removal and later to snow cover. Air temperatures, at night and after snow cover, did not show a significant change in degree-hour accumulation, presumably due to the lateness of the season and general ineffectiveness of the local heating at this time of year. The change, however, was statistically significant throughout 1976.

Air temperature range was similar at all sites prior to treatment. The dissimilarity of soil temperatures both in range and persistence is evident in the temperature frequency diagrams. Limits in snags on maximum soil temperature to only 12-14^{o} C compared to control 22-24^{o} C and grass of 28-30^{o} C suggest a restriction of soil heating by the mass of plant material at the snag site.

Treatment in the snag patch by prescribed fire in 1975 or by the felling of sunlight-obstructing vegetation at the grass site reversed the trend towards a cooler 1976 season shown in the control plot. A moderate increase in air temperatures occurred at the grass site, while air temperature in the snag patch and soil temperatures, both grass and snag, increased substantially. Increases of maxima in air temperature are damped by distance from the exchange surface (soil), but an overall temperature rise in the snag patch was evident. Soil temperatures increased by as much as 26^{o} C in the snag patch

with maxima into the 38-40° C range. Since this is a 3-hour average temperature, the possibility of instantaneous temperatures in excess of these values can reasonably be expected. Soil temperatures have been reported above 67° C at similar elevations on fire-disturbed sites in the Entiat Experimental Forest. (Helvey et al. 1976).

The double mass plots of accumulated degree hours indicate the changing relationships that developed between control and treated plots. Statistically significant changes in the thermal regime due to treatment that might escape notice in other analyses are clearly shown. Some slope changes in the double mass plots, however, occurred other than at treatment time. In general, these changes reflect the changing angular relationships between a particular location and nearby (foliage) and distant (topographic) obstructions in the path of the direct solar beam. The principal effect is to modify through the season the receipt of energy and thereby change the rate and timing of local air and soil heating. This was effectively illustrated by the degree-hour accumulations for each 3-hour period at the soil surface in the snag patch.

Other effects can modify the ratio of degree-hour accumulation.

1. Averaging over 12 hours for degree-hour accumulation minimizes total response at a site.

2. Instability of the soil surface creates differences in local energy exchange. Within the snag patch, burned material and soil components are deposited and transported by gravity, wind, and water. The soil temperature sensor, for example, became partially exposed sometime prior to the first slope change in 1976. It was covered again in early June; this event helps to explain the observed slope change at that time. Some new or residual snags fell near the sensor location (fig. 19) during the period of record and modified local conditions. On the grassy slope, the surface is not static. The sparse vegetative cover offers insufficient protection to erosive forces.

3. Seasonal regrowth or re-establishment of vegetation creates conditions of differential shading. A gradual reduction in the differences between sites will occur from reoccupation.

No measurements will be taken during the 1977 season. After a suitable period of time (3-5 years) depending on regrowth, remeasurement for a season will be considered. To preserve continuity, soil and air temperature sensors will be left in place during the interim.

Results of this study of the changes in thermal regime and continuation of the established trends should assist future evaluation of the effects of prescribed fire at this location. Other investigators deal with successional trends on this and other nearby sites as participants in the overall study of the Grass Camp prescribed burn.[5/]

[5/] Study titles and principal investigators available from Forest Hydrology Laboratory, Wenatchee, Washington.

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Thermal regimes at several locations are examined following prescribed burn or mechanical removal of shading vegetation. While the forested control location indicated a trend in 1976 toward cooler and less variable air and soil temperatures, treated locations responded vigorously to changing site exposure. Moderate increases in air temperature maxima at sensor height of 0.5 m were noted at treated locations while soil temperature maxima at 0.01 m increased by 8° C on the grass slope and by 26° C in the burned snag patch.

KEYWORDS: Temperature (soil), soil temperature, air temperature (-site, fire use, fire effects, prescribed burning, vegetal cover -)fire control.

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